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Apparatus for the Thermal Treatment of Granular Solids

Description

This invention relates to an apparatus for the thermal treatment of granular solids for performing endothermic reactions, wherein CO₂ and/or water is split off from the solids, comprising a reactor to which fuel, O₂-containing gas and pre-heated solids are supplied, wherein the fuel is burnt in the reactor to produce combustion gas with temperatures in the range from 600 to 1500°C, the solids in the reactor are brought in fluidizing contact with the combustion gases, hot exhaust gas from the reactor is used for preheating the solids, and solids are withdrawn from the reactor with temperatures in the range from 400 to 1200°C.

Apparatuses of this kind are known and described for instance in WO 97/18165 A1 and GB 2 019 369, wherein alumina is produced from aluminum hydroxide. WO 97/18165 proposes a circulating fluidized bed for the reactor, and in accordance with GB 2 019 369 A1 the reactor is tubular with a vertical axis.

It is the object underlying the invention to design the above-mentioned apparatus in a simple way, so that a rather small overall height of the plant will be sufficient.

In accordance with the invention this is achieved in that the reactor constitutes an approximately cylindrical, lying cyclone with an approximately horizontal axis of symmetry and swirling, where in an inlet area of the reactor fuel, solids and gas are introduced into the reactor, and from an outlet area of the reactor disposed opposite the inlet area with a horizontal distance solids and hot exhaust gas are withdrawn.

Expediently, at least one preheating cyclone is disposed before the reactor. In this case, preheating the solids can be performed in at least one cyclone by means of exhaust gas from the reactor, the used exhaust gas being withdrawn through a discharge line disposed in the cyclone in the manner of a submerged tube. The discharge line designed like a submerged tube reduces the overall height and at the same time can be used for fixing the cyclone.

Expediently, a cooling means is disposed subsequent to the reactor, so that solids withdrawn from the reactor are cooled in direct contact with O₂-containing gas and the heated O₂-containing gas is introduced into the reactor, where it is required for combustion.

The reactor may be used for the thermal treatment of various solids; by way of example only aluminum hydroxide should be mentioned here, which is converted to alumina. Furthermore, e.g. carbonates may be used, from which CO₂ is thermally expelled, in order to recover oxides. Usually, it will be ensured that at least 50 wt-% of the solids supplied to the reactor have a dwell time of at least 5 seconds in the reactor, where they are heated to the respectively required tempera-

ture. To achieve a prolongation of the dwell time, the hot exhaust gas should expediently be withdrawn from the reactor through a discharge line which in the manner of a suspended tube protrudes into the interior of the reactor by a length T of 0.03 to 0.2 times the entire horizontal length of the reactor. This discharge line in the manner of a suspended tube provides an additional fluidization in the gas, whereby the dwell time thereof and hence also the dwell time of the solids in the reactor is prolonged.

Embodiments of the apparatus will be explained with reference to the drawing, wherein:

- Fig. 1 shows a variant of the apparatus in a view,
- Fig. 2 shows a vertical longitudinal section through the reactor in a schematic representation,
- Fig. 3 shows a section along line III-III of Fig. 2 through the inlet area of the reactor as shown in Fig. 2, and
- Fig. 4 shows a section along line IV-IV through the outlet area of the reactor as shown in Fig. 2.

The central element of the plant in accordance with Fig. 1 is the reactor 1, which approximately has the shape of a lying cylinder with a horizontal axis of symmetry and swirling. The two preheating stages include the cyclones 2 and 3 with associated rising pipes 2a and 3a, to each of which solids are supplied in the base area. The solids to be treated, e.g. aluminum hydroxide, are introduced into the rising pipe 2a through line 4, in which rising pipe they are pneumatically moved into the cyclone 2 by means of hot gas from line 5. The exhaust gas leaves the cyclone 2 through line 2b, which extends downwards inside the cyclone 2 and opens in a gas cleaning 6. The gas cleaning may for instance be designed as wet cleaning or as electrostatic precipitator; cleaned gas is withdrawn via line 7. In practice, any number of preheating stages may be chosen.

Solids preheated in the cyclone 2 leave the same through line 8 and are supplied to the base of the rising pipe 3a. Hot exhaust gas from the reactor 1, which is supplied via line 9, moves the solids to the cyclone 3, and preheated solids are supplied to the reactor 1 through line 10. Exhaust gas leaves the cyclone 3 by flowing downwards in line 5 and is supplied to the first preheating stage. If necessary, part of the solids coming from the cyclone 2 can be admixed to the hot solids of line 11, by-passing the hot area of the plant through line 8a indicated in broken lines.

Through line 12, preheated, O₂-containing gas (e.g. air) is supplied to the reactor 1, and at the same time fuel is supplied from line 13. To minimize the production of ash in the reactor 1, gaseous fuel, e.g. natural gas, is normally used. Usually, the combustion of the fuel with the O₂-containing gas already starts at the gas inlet 1a of the reactor 1, and then a turbulent flow with a horizontal axis of fluidization is formed in the inlet area of the reactor 1; details will be explained below with reference to Figs. 2 to 4.

The hot solid product leaves the reactor 1 through the outlet 1b and is supplied to the cooling through line 11. Like pre-heating, cooling can be effected in one or several stages. In the present case, two cooling stages are represented, which include the cyclones 15 and 16 and the associated rising pipes 15a and 16a. Relatively cold, O₂-containing gas is supplied through line 17 to the base of the rising pipe 15a, where it moves the solid product from line 11 into the cyclone 15. The gas leaves the cyclone 15 through line 12, and the partly cooled solids reach the base of the rising pipe 16a through line 18. Relatively cold O₂-containing gas, e.g. ambient air, is supplied to this rising pipe 16a through line 19, and the solids are pneumatically moved into the cyclone 16. The gas then leaves the cyclone 16 through line 17, and

cooled solids are withdrawn via line 20. Of course, any number of cooling stages may be chosen.

Figs. 2 to 4 show details of the reactor 1 with the gas inlet 1a, a solids inlet 1c, a gas outlet 9a and a solids outlet 1b. The preheated solids are supplied via line 10 and for instance centrally supplied through the inlet 1c to the inlet area of the reactor 1, where they are entrained by the combustion gases coming from the gas inlet 1a. It is possible to supply the solids from line 10 wholly or partly through line 10a indicated in broken lines also through the inlet 1a to the reactor 1.

In particular by choosing the length L and the diameter z of the reactor 1 it should be ensured that at least 50 wt-% of the solids supplied to the reactor have a dwell time of at least 5 seconds and preferably at least 7 seconds in the reactor. The discharge line 9a is preferably designed so as to protrude into the interior of the reactor in the manner of a suspended tube preferably by a length T. This provides favorable flow conditions, which prolong the dwell times in the reactor. The length T preferably is 0.03 to 0.2 times the reactor length L. An advantageous embodiment consists in that the turbulence number, which is the ratio of axial momentum to angular momentum in consideration of the solids momentum and the quotient of inlet and outlet temperature, is larger than 1.5.